Scientific Inquiry

PS-1 The student will demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.

PS-1.5 Organize and interpret the data from a controlled scientific investigation by using mathematics (including formulas and dimensional analysis), graphs, models, and/or technology.

Taxonomy Level: 4.2-B Analyze Conceptual Knowledge
2.1-B Understand Conceptual Knowledge

Key Concepts:

Data	Graphs
Controlled scientific investigation	Direct and Inverse variations (proportion)
Formulas	Models
Dimensional analysis	Technology

Previous/Future knowledge: In the 6th grade, students analyzed and interpreted data to distinguish between an observation and inference (6-1.2). In the 7th grade, students used graphs, tables, and charts to explain the relationship between independent and dependent variables (7-1.5) while they interpreted data to construct explanations and conclusions in the 8th grade (8-1.3). In Physical Science PS-1.1 and PS-1.4, students generate hypotheses and design scientific investigations. This indicator (PS-1.5) expands on these processes by requiring that students organize and interpret data using mathematics with formulas and dimensional analysis, graphs, models, and technology. Indicator PS-1.7 requires that students evaluate results to refute or verify a hypothesis. Significant figures will be addressed in chemistry (C-1.5) and in physics (P-1.5) scientific notation will be addressed.

It is essential for students to

- Organize data which is collected from a controlled scientific investigation.
  - Data should be organized in charts which list the values for the independent variable in the first column and list the values for the dependent variable in a column to the right of the independent variable.

Example Charts:

Independent Variable	Dependent Variable

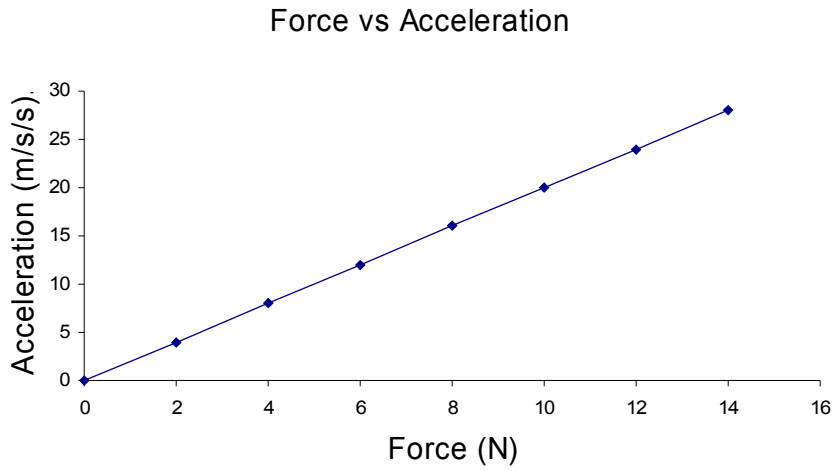
(Or)

Independent Variable				Dependent Variable
	Trial 1	Trial 2	Trial 3	
First value				
Second value				
Third value				
(other values)				

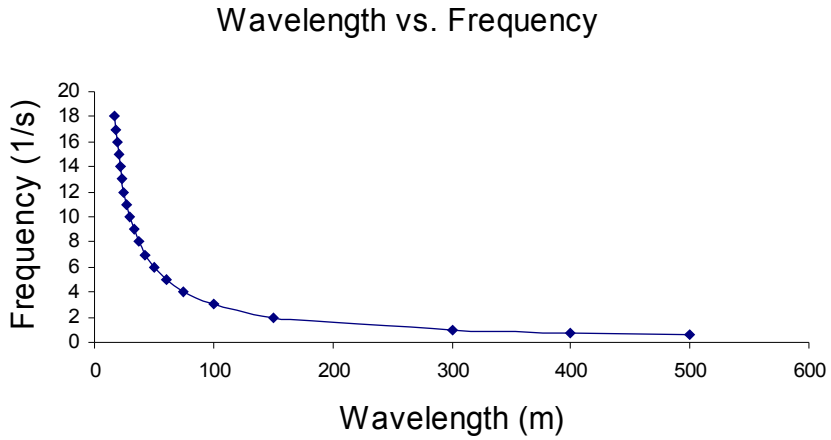
- Use graphs to organize data from controlled investigations.
  - Data should be recorded on a graph with the independent variable plotted on the "X" axis and the dependent variable plotted on the "Y" axis.
  - Choose scales for both the horizontal axis and the vertical axis.
    - There should be two data points more than is needed on the vertical axis.
    - The horizontal axis should be long enough for all of the data points to fit.
    - The intervals on each axis should be marked in equal increments.

- Label each axis with the name of the variable and the unit of measure.
- Title the graph.

- Use the graphs to analyze and interpret data to determine a relationship between the dependent and independent variables.
  - A line graph is used for continuous quantitative data.
  - A bar graph is used for non-continuous data which is usually categorical.
  - A circle graph shows a relationship among parts of a whole. Circle graphs often involve percentage data.
- Recognize the implications of various graphs
  - A *direct variation* (or proportion) is one in which, one variable increases as the other increases or as one variable decreases the other decreases. A straight line with a positive slope indicates a direct relationship that changes at a constant rate. A greater slope indicates an increased rate of change.



  - An *inverse variation* (or proportion) is one in which the product of two quantities is a constant. For example the product of the frequency and the wavelength is equal to the velocity of a wave ($v = f \lambda$). Frequency and wavelength are inversely proportional. As one quantity increases the other quantity decreases.



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Use a *formula* to solve for one variable if given the value for the other variables.

- Use *dimensional analysis* to change the units of the measurement determined, not the value of the measurement itself.
  - It is very important in science to express all numbers with *units of measurement* when appropriate, not just the number as is sometimes done in purely mathematical problems.
  - To change a measurement from liters to milliliters, or grams to kilograms, for example, the measurement can be multiplied by a "conversion factor" that expresses the relationship between the given and asked- for value.
  - This conversion factor is a fraction equal to one and, therefore, the *value* of the original measurement does not change---only the *unit* changes.

$$15 \text{ ~~liters~~} \times \frac{1000 \text{ milliliters}}{1 \text{ ~~liter~~}} = 15{,}000 \text{ milliliters}$$

(conversion factor)

$$15 \text{ ~~milliliters~~} \times \frac{1 \text{ liter}}{1000 \text{ ~~milliliters~~}} = 0.015 \text{ liters}$$

- Understand that a *scientific model* is an idealized description of how phenomena occur and how data or events are related. A scientific model is simply an idea that allows us to create explanations of how we think some part of the world works. *Models* are used to represent a concept or system so that the concept may be more easily understood and predictions can be made.
  - The model of the atom helps us understand the composition, structure, and behavior of atoms. Models for the atom can change as new information and theories explain the atom more completely.
  - No model is ever a perfect representation of the actual concept or system. Models may change over time as scientific knowledge advances.
- Understand that *technology* (tools/machines or processes) can be used to develop better understanding of the science concepts studied. As technology improves, science concepts are studied more completely and more accurately.
- Understand how to organize and analyze data using technology such as graphing calculators or computers.

It is not essential that students memorize formulas for relationships between dependent and independent variables studied.

Assessment Guidelines:

The first objective of this indicator is to *organize* data from a controlled scientific investigation; therefore the primary focus of assessment should be to use formulas, graphs, charts, tables or models to organize the data into a structure that illustrates the relationship between the variables.

Another objective of this indicator is to *interpret* data from a controlled scientific investigation, therefore the primary focus of assessment should be to change one form of data representation into another meaningful representation.

In addition to *organize* and *interpret*, assessments may require that students:

- *Illustrate* the relationship between two variables in a scientific investigation;
- *Interpret* variable relationships using formulas, graphs, models, or technology;
- *Use the procedure* of dimensional analysis to change the units of measurement of data.